

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization International Bureau



(43) International Publication Date
13 January 2005 (13.01.2005)

PCT

(10) International Publication Number
WO 2005/004556 A2

(51) International Patent Classification⁷:

H05H

(21) International Application Number:

PCT/US2004/019590

(22) International Filing Date: 18 June 2004 (18.06.2004)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

60/480,341 20 June 2003 (20.06.2003) US
60/551,725 10 March 2004 (10.03.2004) US

(71) Applicants (for all designated States except US):

DREXEL UNIVERSITY [US/US]; 32nd & Chestnut Streets, Philadelphia, PA 19104 (US). THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS [US/US]; 352 Henry Administration Building, 506 Wright St., Urbana, IL 61801-3640 (US).

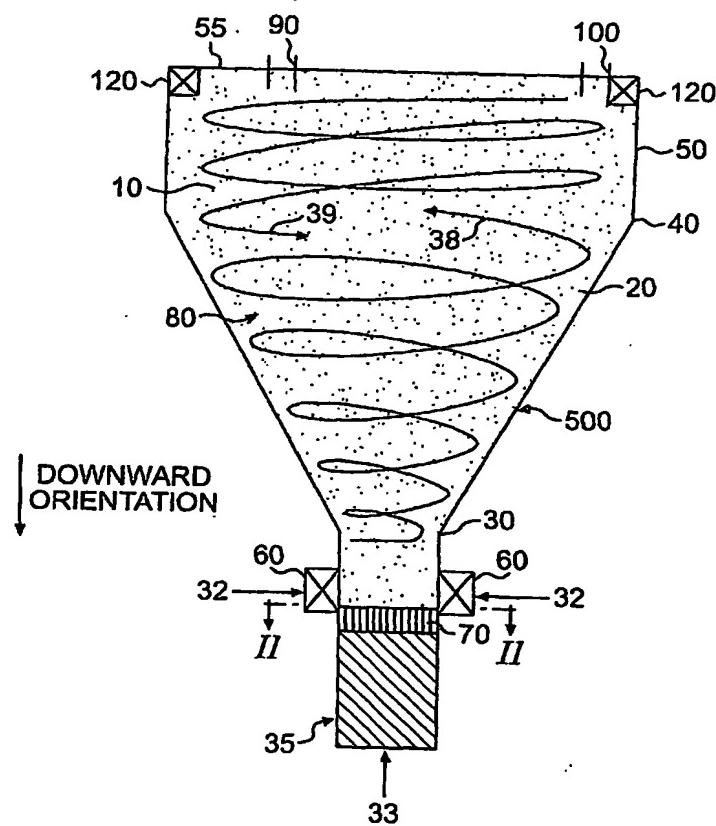
(72) Inventors; and

(75) Inventors/Applicants (for US only): FRIDMAN, Alexander [US/US]; 36 John James Audobon Way, Marlton, NJ 08053 (US). GUTSOL, Alexander, F. [RU/US]; 203 Yorktown Court, Malvern, PA 19355 (US). CHO, Young, I. [US/US]; 433 Tuvira Lane, Cherry Hill, NJ 08003 (US). KENNEDY, Lawrence [US/US]; 24306 West Tumbury Street, Naperville, IL 60564 (US). SAVELIEV, Alexei [BY/US]; 61 West 15th Street, Chicago, IL 60605 (US). ROMANETS, Andrey [RU/RU]; 28 Krasnaya Ploshad Street, App.12, Morshansk, 393950 Tambov Region (RU). MATVEEV, Igor [UA/US]; 7231 Woodley Place, Falls Church, VA 22046 (US). BLANK, Kenneth [US/US]; 3016 W. Coulter Street, Philadelphia, PA 19129 (US).

(74) Agent: DUNLEAVY, Kevin, J.; Knoble Yoshida & Dunleavy, LLC, Suite 1350, Eight Penn Center, 1628 John F. Kennedy Boulevard, Philadelphia, PA 19103 (US).

[Continued on next page]

(54) Title: VORTEX REACTOR AND METHOD OF USING IT



(57) Abstract: A vortex reactor is provided. The vortex reactor includes a reaction chamber formed by a frustum-shaped portion, the narrower part of which is downwardly oriented. Proximate to the narrower part of the frustum-shaped portion, the vortex reactor includes apparatus for creating an axial gas flow and apparatus for creating a circumferential gas flow. The vortex reactor also includes a particulate solid inlet for feeding particulate solids to the reaction chamber. The vortex reactor may optionally include apparatus for generating plasma in the reaction chamber by providing a gliding arc electrical discharge in the reaction chamber. Also provided is a method of processing particulate solids using the vortex reactor of the invention. A reverse vortex plasma reactor (TSAPG) is also provided.



(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— *of inventorship (Rule 4.17(iv)) for US only*

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

**(19) World Intellectual Property Organization
International Bureau**



**(43) International Publication Date
13 January 2005 (13.01.2005)**

PCT

**(10) International Publication Number
WO 2005/004556 A3**

(51) International Patent Classification⁷: B01J 19/08

(72) Inventors; and

(21) International Application Number:

(75) **Inventors/Applicants (for US only):** FRIDMAN, Alexander [US/US]; 36 John James Audobon Way, Marlton, NJ 08053 (US). GUTSOL, Alexander, F. [RU/US]; 203 Yorktown Court, Malvern, PA 19355 (US). CHO, Young, I. [US/US]; 433 Tuvira Lane, Cherry Hill, NJ 08003 (US). KENNEDY, Lawrence [US/US]; 24306 West Tumbury Street, Naperville, IL 60564 (US). SAVELIEV, Alexei [BY/US]; 61 West 15th Street, Chicago, IL 60605 (US). ROMANETS, Andrey [RU/RU]; 28 Krasnaya Ploshad Street, App.12, Morshansk, 393950 Tambov Region (RU). MATVEEV, Igor [UA/US]; 7231 Woodley Place, Falls Church, VA 22046 (US). BLANK, Kenneth [US/US]; 3016 W. Coulter Street, Philadelphia, PA 19129 (US).

(22) International Filing Date: 18 June 2004 (18.06.2004)

11

English

English

(30) Priority Data:

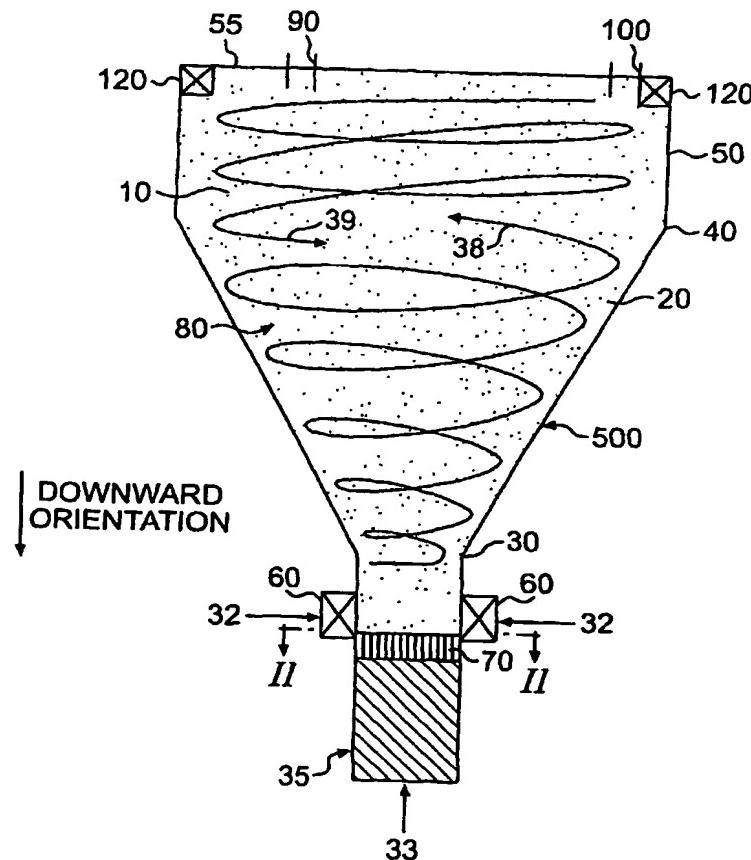
60/480,341 **20 June 2003 (20.06.2003)** **US**
60/551,725 **10 March 2004 (10.03.2004)** **US**

(71) Applicants (*for all designated States except US*):
DREXEL UNIVERSITY [US/US]; 32nd & Chestnut Streets, Philadelphia, PA 19104 (US). THE BOARD OF TRUSTEES OF THE UNIVERSITY OF ILLINOIS [US/US]; 352 Henry Administration Building, 506 Wright St., Urbana, IL 61801-3640 (US).

(74) Agent: DUNLEAVY, Kevin, J.; Knoble Yoshida & Dunleavy, LLC, Suite 1350, Eight Penn Center, 1628 John F. Kennedy Boulevard, Philadelphia, PA 19103 (US)

[Continued on next page]

(54) Title: VORTEX REACTOR AND METHOD OF USING IT



(57) Abstract: A vortex reactor is provided. The vortex reactor includes a reaction chamber formed by a frustum-shaped portion, the narrower part of which is downwardly oriented. Proximate to the narrower part of the frustum-shaped portion, the vortex reactor includes apparatus for creating an axial gas flow and apparatus for creating a circumferential gas flow. The vortex reactor also includes a particulate solid inlet for feeding particulate solids to the reaction chamber. The vortex reactor may optionally include apparatus for generating plasma in the reaction chamber by providing a gliding arc electrical discharge in the reaction chamber. Also provided is a method of processing particulate solids using the vortex reactor of the invention. A reverse vortex plasma reactor (TSAPG) is also provided.



(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— *of inventorship (Rule 4.17(iv)) for US only*

Published:

— *with international search report*

(88) Date of publication of the international search report:

2 June 2005

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,